Automation Of GTAW Process

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ABSTRACT

The soundness of welds is primarily determined by the quality of the root pass. In order to ensure quality welds with full penetration, the gas tungsten arc welding (GTAW) process is widely used in industry. Usually, the quality of manual GTA welding almost solely depends on the experience of individual welders, but the quality of automatic welding is greatly influenced by proper selection and control of welding parameters to overcome the influences from gravity, arc force, surface tension, heat accumulation, joint preparation and fit up precision, etc. Consequently, an automatic-welding system with penetration enhancing activating flux (PEAF) may easily resulting good welding quality, especially in shop floor welding without the joint preparation and good fit up. Automatic GTAW Process is being used widely in the manufacturing industries to weld the pressure vessels, irrespective of the material and its thermal conductivities. Optimal performance of any welding process is based on choosing the right combination of input parameters by trial and error method. This paper deals with the development of an automatic welding system by converting the existing welding machine in to a full fledged automatic machine by addition of wire feeder, a servo controlled carriage, etc. to obtain the optimal combination of input parameters in order to achieve a good quality of weld as per code requirements. Experiments show that the welding quality on steel plates was very successful by using WEAVER and carriage with activated flux.

Key words: Automatic-welding, PEAF-TIG, Wire feeder, Optimization, Servo control

INTRODUCTION

Pipes and Vessels are widely used in almost every field of industry. The safety and reliability of the products are directly affected by weld quality, especially in nuclear power plants. It is difficult for traditional manual welding processes to consistently and efficiently produce quality welds. Therefore, automatic-welding processes have been developed in attempt to produce quality welds in consistent production condition. GTAW is one of the most important arc welding processes and is commonly used for welding of aluminium, stainless steel, magnesium, and titanium, etc. Inert gases are used to shield the weld pool and the HAZ from contaminants from the surrounding atmosphere. Filler wires may or may not be added, depending on the work piece and the desired joint. The quality of GTAW is greatly dependent on the weld joint geometry and proper selection of process parameters such as welding current, current polarity, pulsed current pattern, welding speed, arc length, shielding gas flow rate, joint design, and welding position. In general, GTAW is being carried out by manually and suitable for all positions. It requires high skill to manipulate the welding torch in order to produce sound welds. Only a skilled and qualified welder can produce consistent weld quality. Therefore, welder's experiences and skills are the key factors to achieve welding quality for manual operation. By adopting this system, leads to time consuming and high cost. To overcome these problems, welding automation is essential. Although, the GTA welding process has been used extensively in industry for years, a satisfactory fully automatic system for shop floor welding are very costly. The tolerance of welding parameters is extremely limited for an automatic-welding system. In automatic GTAW welding with activated flux, it is crucial to adjust welding parameters in real-time determination of the degree of root pass penetration. Although, commercial automated welding systems have been available for some time, but the cost of the system is enormous and the small scale industries can not afford the high investment towards this equipment. Hence, in these circumstances, it is essential to convert the conventional welding machine into an automated one. This paper highlights the efforts taken to convert the existing welding machine into a full fledged automatic machine by addition of wire feeder, a servo controlled carriage and torch holder.

GAS TUNGSTEN ARC WELDING (GTAW)

Gas tungsten arc welding, also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non consumable tungsten electrode to conduct electric current to the arc, creating a very precise and local heat zone. This makes the TIG welding process ideal for use, where it is critical not to heat very large areas. The TIG weld puddle and electrode are protected from atmospheric contamination by a shielding gas (usually an inert gas such as argon), and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. Inert gases do not combine with atmospheric gases and ideal for shielding the weld puddle and heat zone. The TIG welding power source should be an AC/DC welder with a high duty cycle. This welder should also have a high frequency either built-in or added onto the machine. The high frequency feature is necessary to maintain a stable arc during the zero voltage conditions in the alternating current cycle. Usually, the TIG torch is designed to deliver both electric current and shielding gas to the weld joint. A constant-current welding power supply produces energy which is conducted across the arc through a column of highly ionized gas and metal vapours known as plasma.

GTAW is most commonly used to weld thin sections of stainless steel and light metals such as aluminium, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing procedures such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques.

OPERATION

Manual gas tungsten arc welding is often considered, the most difficult of all the welding processes commonly used in industry. Because the welder must maintain a short arc length, great care and skill are required to prevent contact between the electrode and the work piece. Unlike most other welding processes, GTAW normally requires two hands, since most applications require that the welder manually feed a filler metal into the weld area with one hand, while manipulating the welding torch in the other. However, some welds combining thin materials (known as autogenous or fusion welds) can be accomplished without filler metal; most notably edge, corner and butt joints.

To strike the welding arc, a high frequency generator provides a path for the welding current through the shielding gas, allowing the arc to be struck when the separation between the electrode and the work piece is approximately 1.5-3 mm. Bringing the two into contact in a "touch start" ("scratch start") also serves to strike an arc. This technique can cause contamination of the weld and electrode. Once the arc is struck, the welder moves the torch in a small circle to create a welding pool, the size of which depends on the size of the electrode and the amount of current. While maintaining a constant separation between the electrode and the work piece, the operator then moves the torch back slightly and tilts it backward about 1015 degrees from vertical. Filler metal is added manually to the front end of the weld pool as it is needed.

Welders often develop a technique of rapidly alternating between moving the torch forward (to advance the weld pool) and adding filler metal. The filler rod is withdrawn from the weld pool each time, the electrode advances, but it is never removed from the gas shield to prevent oxidation of its surface and contamination of the weld. Filler rods composed of metals with low melting temperature, such as aluminium, require that the operator maintain some distance from the arc while staying inside the gas shield. If held too close to the arc, the filler rod can melt before it makes contact with the weld puddle. As the weld nears completion, the arc current is often gradually reduced to allow the weld crater to solidify and prevent the formation of crater cracks at the end of the weld.

THE CHALLENGE

Implementing a reliable and optimization of weld data for Penetration Enhancing activating flux + TIG (PEAF-TIG) and Tungsten Inert Gas (TIG) welding systems.

SYSTEM DESCRIPTIONS

The GTAW system is a highly nonlinear and multivariable welding process. The wire feeder is acquired from existing and unserviceable MIG welding machine. The existing servo controlled light weight (9 kg) Speed WEAVER having four stroke lengths of 7, 12, 25 and 50 mm with a dwell time of 0.06 to 3 s, is mounted on a BUG-O Mark III carriage with is having universal mechanism is used for holding the welding torch and a support bracket for the wire feeder for feeding the filler wire during welding. The wire feeder support bracket with universal adjustment for filler wire has been designed and manufactured in house. The welding head with wire feeder support bracket have been fixed in the carriage having linear speed of 90 -1900 mm/min which moves longitudinally in the guide ways. The block diagram of the process is shown in Figure 1. The existing 'Triodyn' motor generator, welding cable and TIG Torch have been used along with the carriage. Figures 2 and 3 show the universal carriage and test set up.

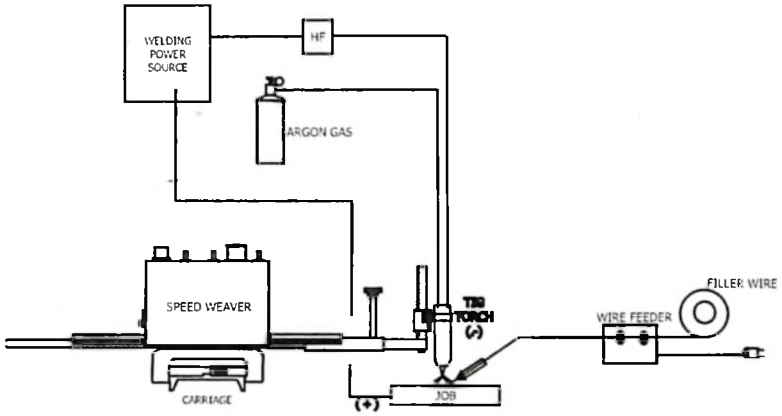

Fig. 1:Block diagram for automated GTAW

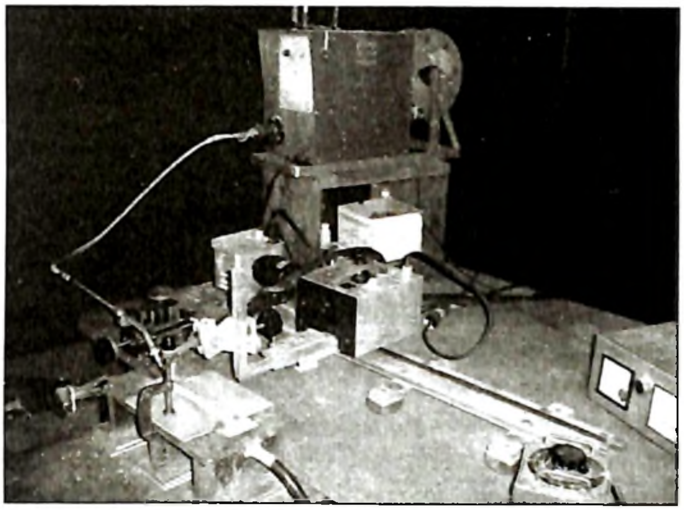

Fig. 2: Automatic welding test setup

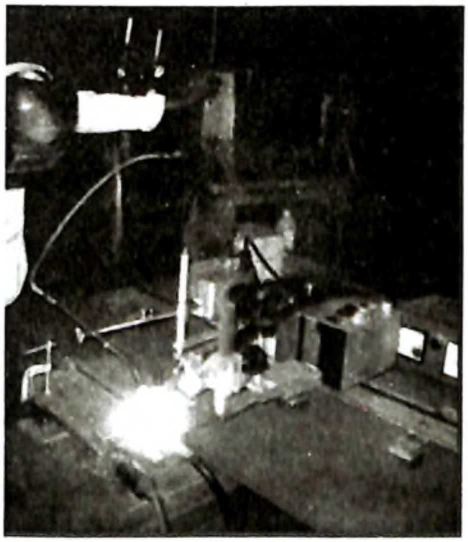

Fig. 3: Progress of PEAF-TIG welding

SOLUTIONS PROPOSED

It was proposed to butt weld 6 mm thickness S.S. (AISI 316) plate in a single pass by adoption of PEAF-TIG welding process with the application of activated flux. The PEAF-TIG arc shows a visible constriction of the arc compared with the more diffuse conventional TIG arc at the same current level. The constricted (by the action of the fluxes) arc will increase the penetration depth to 2.5 times that produced with the conventional TIG process. Activated fluxes that increased weld pool penetration of TIG welding were first utilized in the late 1950s. PEAF-TIG process reduces both the need for edge preparation and increases productivity due to the reduction in the number of weld passes. The concentrated arc energy increases weld penetration through an arc or weld pool mechanism. In PEAF-TIG welding up to 3.2 mm thickness can be welded on stainless steel material without the addition of filler wire. A procedure was qualified to weld up to 3.2 mm. During autogenous welding of higher thickness plate by PEAF-TIG process, sufficient weld reinforcement was not obtained. As per code requirements, a positive weld reinforcement and 6-10% ferrite content in the weld metal are essential. Hence, addition of filler wire with the PEAF-TIG welding is essential, particularly for welding higher thickness plate with single 'V' geometry. In order to cater the above two requirements, automation and hybrid welding process were done with lesser capital investment. The practical proof to the success of the method is explained through successful case studies. The welding object is kept on XY plane. Clamps are used in controlling the position of the weld object with respect to the weld head. The weld head is moved on a XY plane in predefined profile. Along this profile the weld head performs the welding. Fig. 4 shows the completion of PEAF-TIG welding. Here, the required arc distance also determines the position of the weld head and it will be held perpendicular to XY plane.

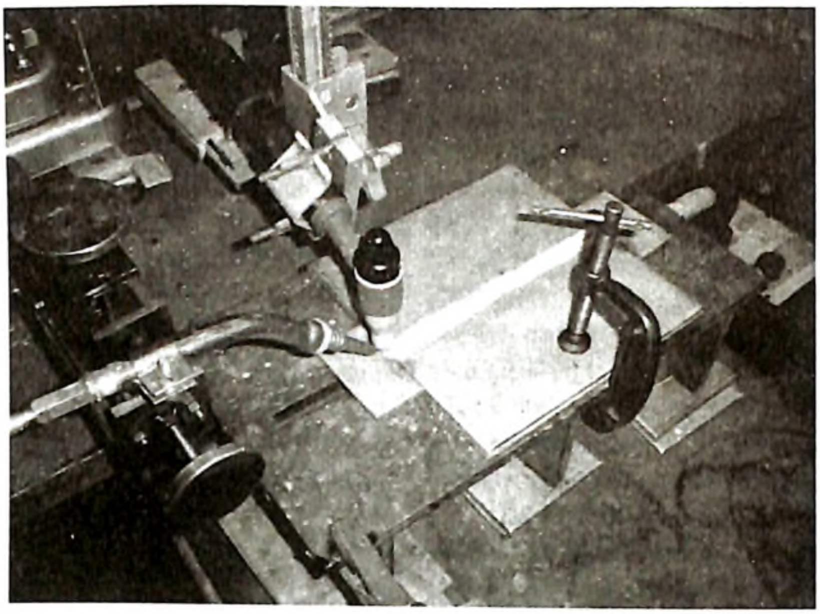
Fig. 4:Completion of PEAF-TIG welding

HYBRID WELDING PROCESSES

PEAF-TIG welding process was developed to solve the problems like, limited gap bridging ability, close edge preparation, limited process efficiency, and use of filler reduces welding speed. This method combines PEAF-TIG welding and TIG welding i.e. two welding processes acting at the same zone one by one i.e. PEAF-TIG + TIG. The hybrid approach provides the deep penetration of a PEAF-TIG. Generally, in arc welding the bead shape becomes more uneven as the welding speed increases. Hybrid welding can provide uniform beads even when the welding speed is high because droplet transfer from the wire takes place in a very short cycle. The welding speed limit for hybrid welding is at least seven times higher than that for arc welding.

CASE STUDY

One S.S. (AISI 316) pad of 6.0 mm thickness with square butt joint and narrow gap, using the automated set up (Photo 2) was welded on top side with the application of activated flux. The full penetration weld was achieved. However, the weld reinforcement was not sufficient as per code. Hence, adoption of hybrid welding process was necessitated to complete the pad i.e. PEAF-TIG on root pass and GTAW with 0.8 mm filler wire on the cap pass.

Similarly, the second S.S. pad of 8.0 mm thickness with square butt joint and narrow gap, using the automated set up was welded by PEAF-TIG process with higher currents on both sides (i.e. one pass on each side) with the application of activated flux. The weld penetration was good and also the weld reinforcement was well within the acceptable limit.

The third S.S. Pad of 6.0 mm thick with single 'V' groove of included angle 70o, 0.5 mm land and a root gap of 1.5 mm was welded by automatic GTAW welding with the addition of 0.8 mm filler wire. The pad was completed with four passes including root pass. The penetration and the weld reinforcement were within the acceptable limit.

Finally, the following NDT and DT tests were carried out on the above three pads: (1). DPT, (2) Radiography, (3) Tensile and (4) Bend tests. All the tests were passed as per code require-ments. Based on the trials and test pads, the welding para-meters were optimized and are shown in Table1.

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CONCLUSION

The weld root pass is a major determinant of the welding quality, and the width of root pass is usually used as indication of full penetration. In this research, an automatic GTAW system with wire feed and the width of weld face is measured to compare with the conventional GTAW and found weld face width is bare minimum. The wire feed controller, wire guide and positioner are developed from previous knowledge and experience in welding.

In the experiment results show that this automatic GTAW system and the automatic PEAF-TIG welding process can increase the production rate by two and four times respectively and also it is possible to achieve good welding quality consistently. The experiment is being implemented successfully to weld pipes and vessels in IG welding position.

REFERENCES

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Table 1 : The optimized welding parameters

Sl. No.	Welding Process	Pad thickness (mm)	Current (amps.)	Volage (V)	Welding Speed (mm/min)	Wire fee (mm/min)
1	PEAF TIG - Root pass	6.0	150	12	150	900
	GTAW - Final pass with filler wire		140	13	150	900
2.	PEAF-TIG one pass on either side	8.0	200	14	150	900
3.	GTAW - Root pass	6.0 with 70" V-groove	110	12	140	950
	GTAW - Remaining 3 passes		140	13	150	1200

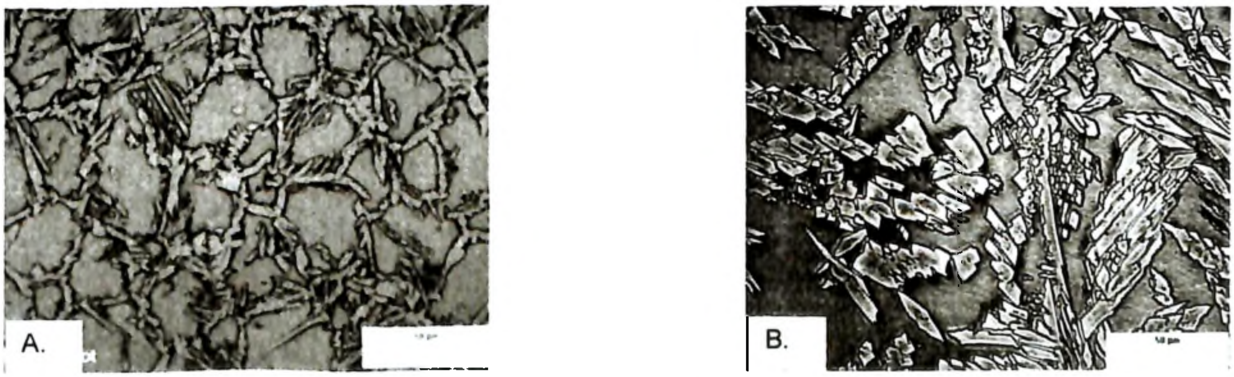

Fig. 5:Micrographic Images of (A) PEAF-TIG weld metal and (B) Traditional GTAW weld metal